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Latest Jurassic Radiolarians from the Torinosu Group in Southwest Japan

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(With 3 Figures, 2 Tables and 3 Plates)

Abstract

Four new species of multi-segmented nassellarians, *Pseudodictyomitra primitiva, Pseudoeucyrtis reticularis, Protunuma japonicus* and *Solenotryma*(?) *ichikawai*, are described from the uppermost Jurassic-lowermost Cretaceous Torinosu Group and its equivalents in Southwest Japan. They are abundantly found in the *Pseudodictyomitra primitiva-Pseudodictyomitra* sp. A Assemblage together with other nassellarians and spumellarians. The age of this assemblage is most probably assigned to latest Jurassic (Tithonian).

Introduction

Jurassic radiolarian biostratigraphy of Japan has been established in broad lines through recent extensive contribution by many workers (cf. NAKASEKO *et al.*, 1983). A correlation of radiolarian zones with Europian stages is not adequately settled because, in Japan, Jurassic radiolarians rarely coexist with other diagnostic taxa for age determination such as ammonites. As an exception, the uppermost Jurassic to lowermost Cretaceous Torinosu Group and its equivalents contain various kinds of mega- and micro-fossils such as mollusks, corals, stromatoporoids, radiolarians, calcareous nannofossils and so on. Therefore these strata are expected to provide tie-points of biostratigraphy among many kinds of fossil taxa.

The Torinosu Group and its equivalents contain the radiolarian assemblage which is called the *Dictyomitra* sp. B—*Dictyomitra* sp. A Assemblage by MATSUOKA & YAO (1981) and YAO *et al.* (1982). This assemblage is renamed here as the *Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage as a result of description of the diagnostic species. In this paper, four new species of multi-segmented nassellarians, which characterize the *P. primitiva—P.* sp. A Assemblage, are described from the Torinosu Group of the type area, the Sakawa area, Kochi Prefecture and from the Yura Formation (the equivalent of the Torinosu Group) of the Kii-Yura area, Wakayama Prefecture. In addition, the age assignment of the assemblage is given and the comparison of the assemblage with other radiolarian assemblages proposed by several workers in Japan is discussed.

Geologic Setting

The Torinosu Group is the clastic sequences of (Middle-) Late Jurassic age containing characteristic reefal limestones (Torinosu limestone) in the Chichibu Terrane.

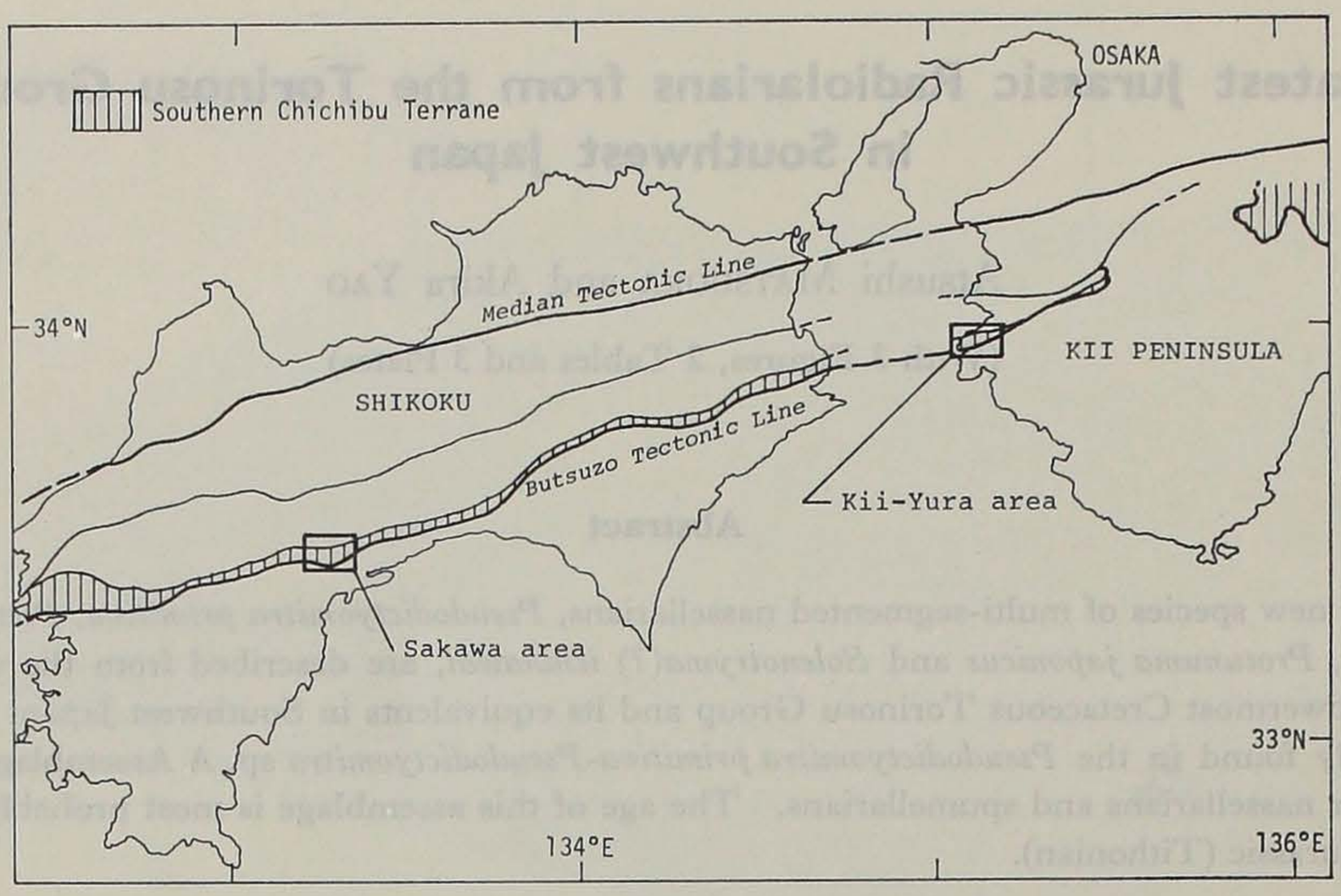

Fig. 1. Index map of the study areas.

The name, Torinosu Group, has been used not only as a term for the lithostratigraphic unit in the Sakawa area of the western part of Kochi Prefecture (Fig. 1) but also as a general term for the equivalents of the Torinosu Group which are intermittently distributed from Kanto Mountains to Kyushu over a distance of about 1000 kilometers. In this paper, the term, Torinosu Group, is used restrictively for the strata distributed arround the type area. The Torinosu Group and its equivalents have been regarded to be distributed in the Middle and Southern Chichibu Terranes. On the basis of fossil evidence of ammonites and radiolarians, ICHIKAWA *et al.* (1982) summarized that those in the Middle Chichibu Terrane of central and western Shikoku consist predominantly of middle Jurassic sequence whereas those in the Southern Chichibu Terrane of Shikoku and western coast of the Kii Peninsula are latest Jurassic to earliest Cretaceous in age. MATSUOKA (in press) states that it is desirable to apply the name Torinosu Group only to the strata in the Southern Chichibu Terrane.

The samples treated here come from the Torinosu Group of the Sakawa area, Kochi Prefecture and from the Yura Formation of the Kii-Yura area, Wakayama Prefecture (Figs. 1–3).

1. Sakawa area (Fig. 2)

The Southern Chichibu Terrane of this area is composed of the Togano Group (Middle Triassic—Upper Jurassic), the Naradani Formation (Upper Jurassic), the Torinosu Group (uppermost Jurassic—? Lower Cretaceous), the Yamanokami Formation (Lower Cretaceous) and the Bandagamori Formation (Upper Jurassic—) (MATSUOKA, 1984a). These strata are arranged in E-W direction and are in fault contact with each other. The Torinosu Group consists of terreginous clastic rocks associated with reefal limestones. Stratigraphy of the Torinosu Group was investigated by KIMURA (1956). However, the

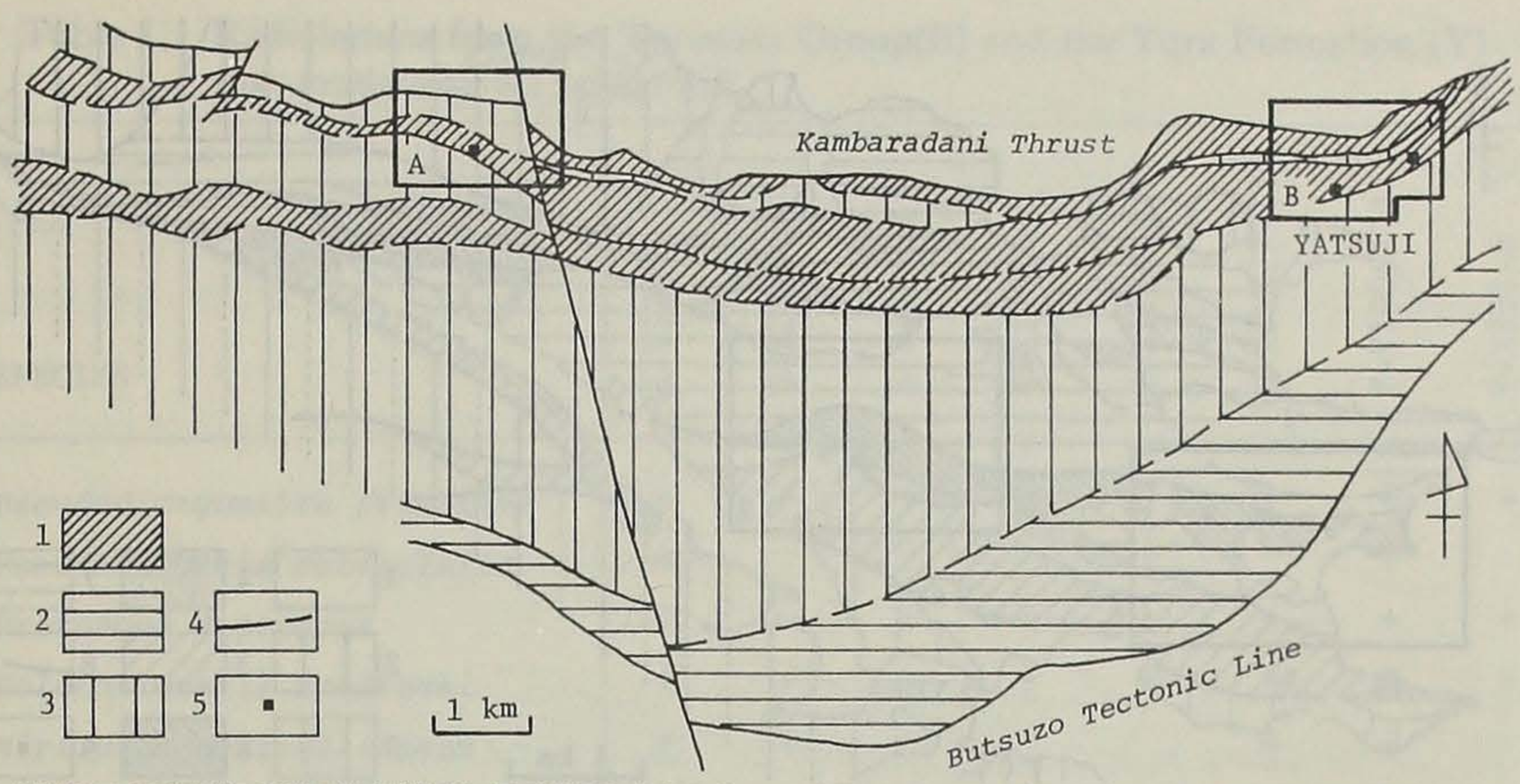

Fig. 2. Geologic map and radiolarian localities in the Sakawa area.
(From 1: 25,000 topographic maps of "Choja" and "Sakawa" published by Geographical Survey Institute of Japan)
1: Yamanokami Formation (Lower Cretaceous), Torinosu Group (uppermost Jurassic—? Lower Cretaceous) and Naradani Formation (Upper Jurassic), 2: Bandagamori Formation (Upper Jurassic—), 3: Togano Group (Middle Triassic—Upper Jurassic), 4: fault, 5: locality of radiolarians.

results by him need to be revised in some points. For example, in the Yatsuji area, where KIMURA (1956) showed that lithologic succession of the Torinosu Group was typically observable, the group is divided into two parts by tectonic insersion of a chert layer of the Togano Group. Details of the stratigraphy of the Torinosu Group will be described in another paper. Many paleontologists have worked on fossils from the Torinosu Group, because this group abundantly contains various mega fossils. *Aulacosphinctoides* cf. *steigeri* (SHIMIZU), which was reported by KOBAYASHI (1935) from this group, is regarded as a Tithonian ammonite by SATO (1962) who summarized Japanese Jurassic ammonite biostratigraphy. Quite recently, AITA and OKADA (1984 and in prep.) have reported latest Jurassic or eaıliest Cretaceous calcareous nannofossils from a marly limestone of this group.

2. Kii-Yura area (Fig. 3)

According to YAO (1984), the Southern Chichibu Terrane of this area is composed of the Chuki Group (upper Lower Jurassic to Barremian) and the Kobiki Formation

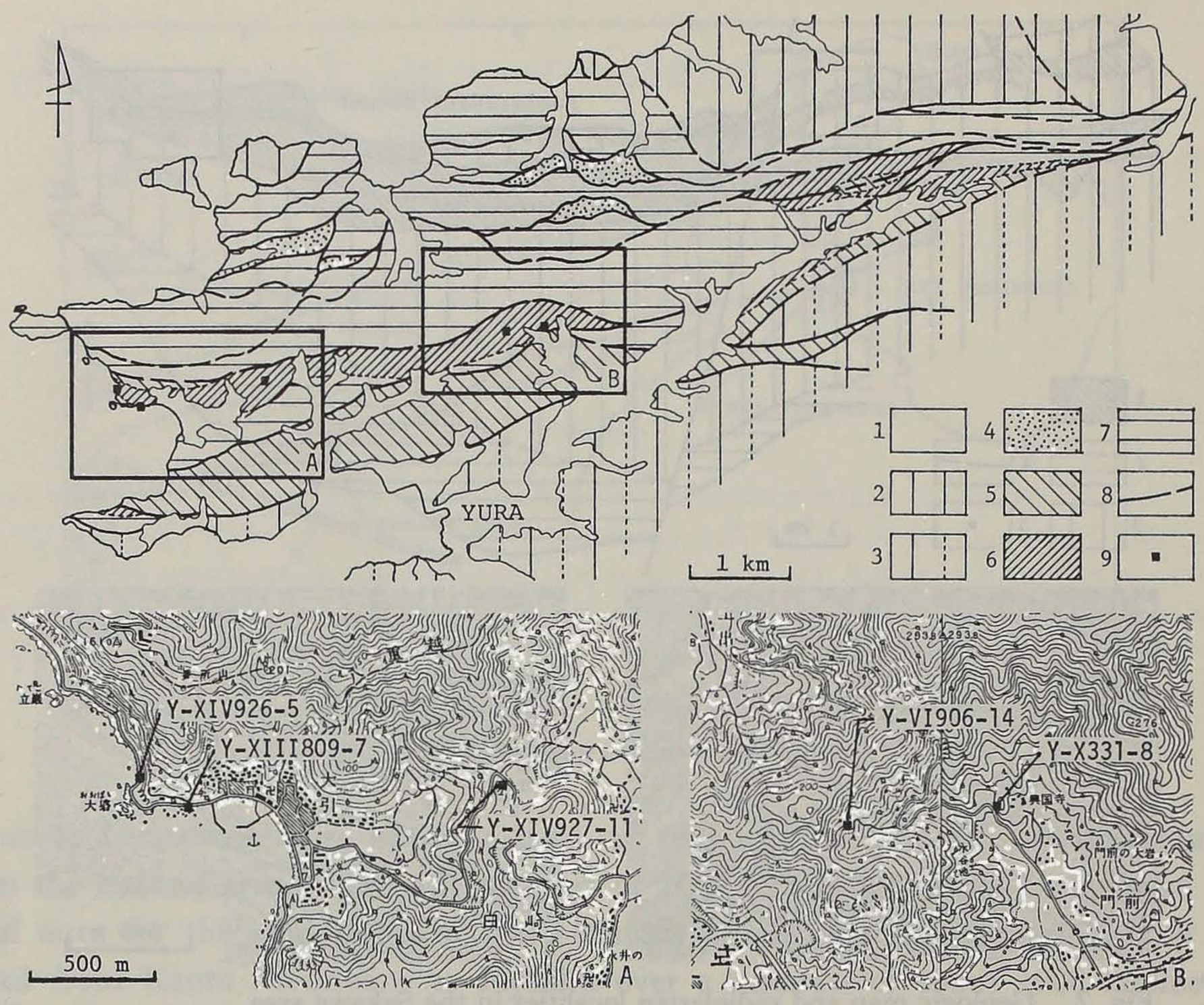

Fig. 3. Geologic map and radiolarian localities in the Kii-Yura area.
(From 1:25,000 topographic maps of "Kii-Yura" and "Taie" published by Geographical Survey Institute of Japan)
1: Quaternary, 2: Izeki Formation (Turonian-Santonian) and Miogawa Formation (upper Albian-Cenomanian), 3: Terasoma Formation (Turonian-Santonian) and Shirama Formation (Aptian?-Cenomanian), 4: Kobiki Formation (Coniacian-Santonian), 5: Kamiya Formation (Valanginian-Barremian), 6: Yura Formation (Tithonian-Berriasian), 7: Obiki Formation (upper Lower Jurassic-Tithonian), 8: fault, 9: locality of radiolarians.

(Coniacian-Santonian). The Chuki Group is subdivided into the Obiki Formation, the Yura Formation and the Kamiya Formation in ascending order. The Yura Formation has been regarded as an equivalent of the Torinosu Group on the basis of its litho- and biofacies. A detailed geologic description of this formation is given in YAO (1984). A Tithonian ammonite, *Taramelliceras* (*Parastreblites*) sp. (identified by Tadashi SATO) was found from chert sandstone of the Yura Formation (KAKEHI *et al.*, 1965).

Paleontological Note

Materials: The sample localities are shown in Fig. 2 for the Sakawa area and Fig. 3 for the Kii-Yura area, respectively. The lithology of each sample is given in Table 1. Type specimens of new species come from a sample (Y-VI906–14) taken from the Yura Formation in the Kii-Yura area because the sample contains the better preserved radiolarians than other samples treated in this study.

Table 1. Radiolarians from the Torinosu Group(S) and the Yura Formation (Y). ms: mudstone, at: acidic tuff.

SPECIES \ SAMPLE	S-VI2801	S-I2812	S-III1403	Y-XIV926-5	Y-XIII809-7	Y-XIV927-11	Y-VI906-14	Y-X331-8
Pseudodictyomitra primitiva	+	+	+	+	+	+	+	+
Pseudoeucyrtis reticularis	+						+	
Protunuma japonicus	+		+	+	+	+	+	+
Solenotryma(?) *ichikawai*	+	+	+	+	+	+	+	+
Mirifusus mediodilatatus	+	+				+	+	
Parvicingula mashitaensis						+	+	
Archaeodictyomitra apiara					+	+		
A. minoensis	+			+		+		
Cinguloturris carpatica	+		+	+	+	+	+	+
Podocapsa amphitreptera							+	
Eucyrtidium(?) *ptyctum*	+		+		+	+	+	+
Foremanella diamphidia	+						+	
Sphaerostylus sp. A	+	+	+	+		+	+	+
Tricolocapsa sp. A	+	+	+	+	+	+	+	+
Stichocapsa sp. A	+	+	+	+	+	+	+	+
Spongocapsula sp. A	+	+	+	+	+	+	+	
Pseudodictyomitra(?) sp. D	+		+	+	+	+	+	+
LITHOLOGY	ms	ms	ms	ms	ms	at	at	ms

Preparation Method: Samples were treated in the same manner as given in YAO (1984).

Register and Depository: Type and figured specimens of new species are registered and deposited in the Department of Geosciences, Osaka City University. In the systematic description and explanation of plates, the OCU MR number is the register number of the specimens in that Department. The number following the sample number indicates the slide number and position of the specimen on slide or in the case of metal-coated material for SEM, the number of metal stab and position on the stab.

Systematic Paleontology

Subclass **Radiolaria** MÜLLER 1858

Superorder **Polycystina** EHRENBERG 1838, emend. RIEDEL 1967

Order **Nassellaria** EHRENBERG 1875

Remarks: The genera are alphabetically arranged in this paper because clasification

of the family level is at present not adequately settled.

Genus *Protunuma* ICHIKAWA & YAO 1976

Type species: *Protunuma fusiformis* ICHIKAWA & YAO, 1976, p. 116, pl. 2, figs. 1–4.

Protunuma japonicus MATSUOKA & YAO, n. sp.

(Pl. 1, Figs. 11–15; Pl. 3, Figs. 6–9)

1969. *"Lithocampe"* aff. *brouweri* (TAN)—YAO and ICHIKAWA, pl. 1, figs. 3–4.
1981. *Protunuma fusiformis* ICHIKAWA & YAO—MIZUTANI, pl. 63, figs. 1, 8; pl. 64, fig. 3.
1982. *Protunuma* sp. D—YAO *et al.*, pl. 4, fig. 24.
1982. *Protunuma fusiformis* ICHIKAWA & YAO—ADACHI, pl. 3, figs. 9–10.
1982. *Protunuma* sp.—IMOTO *et al.*, pl. 3, fig. 10.
1983. *Protunuma fusiformis* ICHIKAWA & YAO—NISHIZONO & MURATA, pl. 4, fig. 15.
1984. *Protunuma* sp. D—YAO, pl. 3, fig. 17.
1984. *Protunuma fusiformis* ICHIKAWA & YAO—OZVOLDOVA & SYKORA, pl. 8, figs. 6–7.

Description: Spindle-shaped shell with three stable internal septa and two unstable internal septa between which the fomer is put. According to the number of unstable internal septa, segments varing in number from 5 to 7. External segmental division indistinct except for collar stricture. Cephalis spherical internally without pores. Six to 8 longitudinal plicae visible in lateral view. Most of plicae running from cephalic surface to ditsal end. Two to 4 rows of pores present between neighboring two longitudinal plicae. Pores very small, circular, uniform in size, arranged diagonally. Aperture small, circular, constricted.

Measurements (in microns; based on 21 specimens): Height overall, 150–217 (av., 176); maximum width of shell, 75–130 (av., 106); diameter of cephalis, 17–22 (av., 20).

Remarks: *Protunuma japonicus* n. sp. is similar to *Protunuma fusiformis* ICHIKAWA & YAO and *Protunuma turbo* MATSUOKA in outer shape, but differs from them in certain points. *P. japonicus* consists of 5 to 7 segments, while *P. fusiformis* is composed of 5 segments and *P. turbo* is composed of 3 segments. *P. japonicus* with 5 segments, which occurs rarely, is distinguished from *P. fusiformis* in size of the second segment, namely that of the former is larger than that of the latter. External segmental division is indistinct in *P. japonicus* except for collar stricture, while lumber stricture is recognizable in *P. fusiformis* and *P. turbo* because abdomen expands more strongly than thorax in the latter two species.

The known ranges of these species are different, that is, the occurrence of *P. japonicus*

is restricted in the *Gongylothorax sakawaensis—Stichocapsa naradaniensis*, the *Tricolocapsa* sp. O and the *Pseudodictyomitra primitiva—P.* sp. A Assemblage-zones (Upper Jurassic) whereas *P. fusiformis* and *P. turbo* are found in the *Unuma echinatus* and/or *Lithocampe* (?) *nudata* Assemblage-zones (Middle Jurassic).

Etymology: This species is named from the Latin adjective *japonicus*, meaning Japanese.

Type specimens: Holotype, OCU MR 2736 (Pl. 3, Fig. 6); Paratype, OCU MR 2737 (Pl. 3, Fig. 7).

Type locality: Holotype and Paratype from Loc. Y-VI906-14.

Genus *Pseudodictyomitra* Pessagno 1977

Type species: Pseudodictyomitra pentacolaensis Pessagno, 1977b, p. 50–51, pl. 8, figs. 3, 17, 23; pl. 12, fig. 10.

Pseudodictyomitra primitiva Matsuoka and Yao, n. sp.

(Pl. 1, Figs. 1–6; Pl. 3, Figs. 1–4)

1982. *Dictyomitra* sp. B—Yao *et al.*, pl. 4, fig. 27.
1982. unnamed multicyrtoid nassellaria—Adachi, pl. 2, fig. 4.
1983. *Dictyomitra* sp. B—Yao, fig. 3–14.
1983. *Hsuum* sp. indet.—Ishizuka *et al.*, pl. 1, figs. 1, 6.
1984. *Dictyomitra* sp. B—Yao, pl. 3, figs. 1 and 3, not 2.

Description: Shell elongate, conical with 7 to 10 postabdominal segments. Cephalis small, dome-shaped without apical horn. Cephalis and thorax imperforate with smooth surface, or with weakly developed costae. Each of subsequent segment excluding 1 or 2 final postabdominal ones truncate cone-shaped. Width of segments expanding rapidly in proximal part and gradually in distal part except for last 1 or 2 segments which become narrow and subcylindrical. Abdomen and postabdominal segments separated from each other by a single row of small, circular to elliptical pores situated in strictures at joints; occasionally double rows of pores, which are arranged diagonally, present in 1 or 2 final strictures. Abdomen and postabdominal segments costate with about 30–40 costae (15–20 visible laterally) which do not traverse the strictures of the postabdominal segments.

Measurements (in microns; based on 15 specimens): Height overall, 185–258 (av., 225); maximum width of shell, 80–98 (av., 87).

Remarks: Although *Pseudodictyomitra primitiva* n. sp. lacks two rows of primary pores in strictures at joints except for final 1 or 2 ones in some specimens, it is assigned to *Pseudodictyomitra* because other morphological features such as its lobate form and presence of discontinuous costae agree with definition of the genus. *P. primitiva* can be a primitive form of *Pseudodictyomitra* because forms related to this genus are not

found in lower zones than the *Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage-zone so far as is known. *P. primitiva* differs from other species of *Pseudodictyomitra* by lacking two rows of primary pores in the position of the strictures except for 1 or 2 final strictures in some specimens. *P. primitiva* is similar to *Pseudodictyomitra* (?) sp. D (Pl. 2, Figs. 6–7) in shape but differs from the latter species by having stronger strictures and lacking complicated ornamentation on outer surface by combination of ridges and depressions. The first occurrence of *P.* (?) sp. D, which is within the *Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage-zone (early Late Jurassic; MATSUOKA, 1984b), is prior to that of *P. primitiva*.

Etymology: The name is derived from the Latin adjective *primitivus*, meaning primitive.

Type specimens: Holotype, OCU MR 2729 (Pl. 3, Fig. 4); Paratype, OCU MR 2728 (Pl. 3, Fig. 3).

Type locality: Holotype and Paratype from Loc. Y-VI906-14.

Genus *Pseudoeucyrtis* PESSAGNO 1977

Type species: *Eucyrtis*(?) *zhamoidai* FOREMAN, 1973, p. 264, pl. 10, figs. 9–10; pl. 16, figs. 1–2.

Pseudoeucyrtis reticularis MATSUOKA & YAO, n. sp.

(Pl. 1, Figs. 16–21; Pl. 3, Figs. 14–17)

1981. *Pseudoeucyrtis* sp.—MIZUTANI, pl. 61, figs. 5, 6.
1982. *Pseudoeucyrtis* sp. A—YAO *et al.*, pl. 4, fig. 25.
1983. *Pseudoeucyrtis* sp. A—YAO, fig. 3–15.
1984. *Pseudoeucyrtis* sp. A—YAO, pl. 3, fig. 18.
1984. *Pseudoeucyrtis* sp.—OZVOLDOVA & SYKORA, pl. 10, figs. 5, 6, 8; pl. 13, fig. 2.
1984. *Pseudoeucyrtis* sp.—TAKASHIMA & KOIKE, pl. 2, fig. 1.

Description: Shell slender, spindle-shaped with a stout apical horn and a stout basal spine. Proximal part segmented by internal septa while distal part lacking them and forming a large cavity. Segments varing in number from 4 to 7, according to the number of internal septa. Cephalis spherical or subspherical internally and relatively large. The remaining segments except for the last large one cylindrical and same in height. Pores circular, diagonally arranged and densely spaced. Pore frames polygonal in outline. Pores and pore frames incresaing in size distally.

Measurements (in microns; based on 18 specimens): Height overall, 282–380 (av., 340); maximum width of shell, 63–100 (av., 82); diameter of cephalis, 22–34 (av., 28).

Remarks: Height of shell of *Pseudoeucyrtis reticularis* n. sp. varies among specimens. Short specimens are slender biconical in outline, while long specimens are cylindrical in

the middle part. *Pseudoeucyrtis* sp. from the Western Carpatians (OZVOLDOVA & SYKORA, 1984; pl. 10, fig. 6) may correspond to the longest form of this species. *P. reticularis* differs from *Pseudoeucyrtis zhamoidai* (FOREMAN) and *Pseudoeucyrtis paskentaensis* PESSAGNO by having a smaller number of segments, by having pores and pore frames increasing in size distally and by having a stout basal spine.

Etymology: This species is named from the Latin adjective *reticularis,* meaning reticular.

Type specimens: Holotype, OCU MR 2755 (Pl. 3, Fig. 15); Paratype, OCU MR 2756 (Pl. 3, Fig. 16).

Type locality: Holotype and Paratype from Loc. Y-VI906-14.

Genus *Solenotryma* FOREMAN 1968

Type species: *Solenotryma dacryodes* FOREMAN, 1968, p. 33–35, pl. 4, fig. 8.

Solenotryma(?) *ichikawai* MATSUOKA and YAO, n. sp.

(Pl. 1, Figs. 7–10; Pl. 3, Figs. 5, 10–13)

cf. 1974. *Solenotryma* sp.—RIEDEL & SANFILIPPO, pl. 9, figs. 9–10; pl. 13, fig. 11.
1982. *Solenotryma* sp. B—YAO *et al.*, pl. 4, fig. 23.
1984. *Solenotryma* sp. B—YAO, pl. 3, figs. 15–16.

Description: Shell ovate to elongate, consisting of 5 to 12 segments. Cephalis spherical or subspherical without apical horn, partly encased in thoracic cavity. Thorax truncated cone-shaped with a large, circular aperture. Abdomen relatively large, with constricted aperture and hidden partly or completely in the fourth segmental cavity. Cephalis, thorax and abdomen form together a fundamental part of the shell. Postabdominal segments expanding rapidly in width in proximal part where weak strictures are present. Individual postabdominal segment truncated oval in shape with a constricted aperture. Distal part of all postabdominal segments but final one hidden in subsequent postabdominal cavity. Shell generally smooth, perforate but provided with small numerous projections. Pores small, circular, irregularly arranged, varying slightly in size, closely or widely spaced.

Measurements (in microns; based on 17 specimens): Hieght overall, 158–255 (av., 191); of fundamental part of shell (cephalis, thorax and abdomen), 45–66 (av., 52); maximum width of shell, 72–120 (av., 99).

Remarks: Although *Solenotryma*(?) *ichikawai* n. sp. is a species of multicyrtoids consisting of more than four segments and does not conform to the generic definition of *Solenotryma* as given by FOREMAN (1968), this species is apparently related to *Solenotryma* which consists of both a fundamental part and an appendage of the shell. *S.*(?) *ichikawai* differs from *Solenotryma dacryodes* FOREMAN by having a greater number of segments. The degree of encasement of segments into subsequent segments varies among specimens.

Etymology: *Solenotryma*(?) *ichikawai* n. sp. is named for Dr. K. ICHIKAWA in honor of his contributions to the study of Mesozoic radiolarians.

Type specimens: Holotype, OCU MR 2745 (Pl. 3, Fig. 5); Paratype, OCU MR 2748 (Pl. 3, Fig. 12).

Type locality: Holotype and Paratype from Loc. Y-VI906-14.

Remarks on the *Pseudodictyomitra primitiva*—*Pseudodictyomitra* sp. A Assemblage

In this chapter, we start with listing up species of the *Pseudodictyomitra primitiva*—*Pseudodictyomitra* sp. A Assemblage and comparison of this assemblage with the biostratigraphically just sub- and superjacent assemblages set up by ourselves. Secondly, the age of this assemblage is discussed on the basis of fossil evidence of ammonites, calcareous nannofossils and characteristic species of radiolarians from the Torinosu Group and its equivalents. Lastly, *P. primitiva*—*P.* sp. A Assemblage is compared with other radiolarian assemblages proposed by several workers in Japan.

The *Pseudodictyomitra primitiva*—*Pseudodictyomitra* sp. A Assemblage

This assemblage is recognized in the Torinosu Group and its equivalents of Southwest Japan. This assemblage cantains following species.

Pseudodictyomitra primitiva MATSUOKA & YAO (Pl. 1, Figs. 1–6; Pl. 3, Figs. 1–4)
Pseudoeucyrtis reticularis MATSUOKA & YAO (Pl. 1, Figs. 16–21; Pl. 3, Figs. 14–17)
Protunuma japonicus MATSUOKA & YAO (Pl. 1, Figs. 11–15; Pl. 3, Figs. 6–9)
Solenotryma(?) *ichikawai* MATSUOKA & YAO (Pl. 1, Figs. 7–10, Pl. 3, Figs. 5, 10–13)
Mirifusus mediodilatatus (RÜST) (Pl. 2, Fig. 2)
Parvicingula mashitaensis MIZUTANI (Pl. 2, Fig. 1)
Archaeodictyomitra apiara (RÜST) (Pl. 2, Fig. 4)
Archaeodictyomitra minoensis (MIZUTANI) (Pl. 2, Fig. 5)
Cinguloturris carpatica DUMITRICA (Pl. 2, Fig. 13)
Podocapsa amphitreptera FOREMAN (Pl. 2, Fig. 10)
Eucyrtidium(?) *ptyctum* RIEDEL & SANFILIPPO (Pl. 2, Fig. 8)
Foremanella diamphidia (FOREMAN) (Pl. 2, Fig. 9)
Sphaerostylus sp. A (Pl. 2, Fig. 14)
Tricolocapsa sp. A (Pl. 2, Fig. 12)
Stichocapsa sp. A (Pl. 2, Fig. 11)
Spongocapsula sp. A (Pl. 2, Fig. 3)
Pseudodictyomitra sp. A (YAO *et al.*, 1982, pl. 4, fig. 26)
Pseudodictyomitra(?) sp. D (Pl. 2, Figs. 6–7)

In middle Upper Jurassic to lowermost Cretaceous strata of the Southern Chichibu Terrane in Southwest Japan, we recognized three successive radiolarian assemblages, namely the *Tricolocapsa* sp. O Assemblage (YAO *et al.*, 1982), the *P. primitiva*—*P.* sp.

Table 2. List of characteristic species of the *Tricolocapsa* sp. O (TO), the *Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A (P-P) and *Pseudodictyomitra* cf. *carpatica* (Pc) Assemblages.

SPECIES \ ASSEMBLAGE	T O	P-P	P c
Hsuum maxwelli	+		
Tricolocapsa sp. O	+ +	-	
Eucyrtidium(?) *ptyctum*	+	-	
Cinguloturris carpatica	+	+	
Protunuma japonicus	+	+ +	
Pseudodictyomitra(?) sp. D	+	+	-
Mirifusus mediodiratatus	+	+	+
Tricolocapsa sp. A	+	+ +	+
Stichocapsa sp. A	+	+	+
Solenotryna(?) *ichikawai*	+	+ +	+
Pseudoeucyrtis reticularis		+	
Pseudodictyomitra primitiva		+ +	-
P. sp. cf. *P. carpatica*			+ +
Eucyrtidium(?) *ozaiense*			+
E.(?) sp. C			+

+ + abundant + common - rare

A Assemblage and *Pseudodictyomitra* cf. *carpatica* Assemblage (Nakatani & Yao, 1980; Matsuoka & Yao, 1981) in ascending order. Each assemblage is characterized by certain species as shown in Table 2. In the *Tricolocapsa* sp. O Assemblage, *T.* sp. O, *Eucyrtidium*(?) *ptyctum* Riedel & Sanfilippo and *Hsuum maxwelli* Pessagno are commonly recognized, while in the *P. primitiva—P.* sp. A Assemblage, the former two are rarely found and the last species is not found at present. *Protunuma japonicus* Matsuoka & Yao and *Cinguloturris carpatica* Dumitrica are found in both assemblages. *P. primitiva* Matsuoka & Yao abundantly occurs in the *P. primitiva—P.* sp. A Assemblage but is not found in the *T.* sp. O Assemblage though *P.*(?) sp. D (Pl. 2, Figs. 6–7), which is morphologically similar to *P. primitiva* Matsuoka & Yao, is recognized in the *T.* sp. O Assemblage. The *P. primitiva—P.* sp. A assemblage is characterized by abundant occurrence of *P. primitiva* Matsuoka & Yao, *P. reticularis* Matsuoka & Yao and *P. japonicus* Matsuoka & Yao, while *Pseudodictyomitra* cf. *carpatica* Assemblage is characterized by abundant occurrence of *Pseudodictyomitra* sp. cf. *P. carpatica* (Lozyniak) and by presence of *Eucyrtidium*(?) *ozaiense* (in Aita & Okada, 1984 and in prep.) and *Eucyrtidium*(?) sp. C (in Nishizono & Murata, 1983).

Yao (1984) divided the uppermost Jurassic—lower Cretaceous strata of the Kii-Yura area into two radiolarian zones, namely the *Pseudodictyomitra primitiva—P.* sp. A Assemblage-zone (s.l.) and the *Sethocapsa uterculus* Assemblage-zone in ascending order;

the former assemblage-zone approximately corresponds to the Yura Formation (the equivalent of the Torinosu Group). On the basis of the radiolarian specific association, it is now considered that the *Pseudodictyomitra* cf. *carpatica* Assemblage represents the radiolarian fauna occurring in the upper part of the *Pseudodictyomitra primitiva—P.* sp. A Assemblage-zone (s.l.).

Quite recently, AITA & OKADA (1984 and in prep.) reported latest Jurassic or earliest Cretaceous calcareous nannofossils from the Torinosu Group in the type area (Sakawa area) and in the western extension of the type area where radiolarian fossils coexist with nannofossils. According to them, the middle to late Tithonian calcareous nannofossil flora is identified in the samples taken from the Sugegadani section; one of the same samples yields radiolarian fossils such as *Pseudodictyomitra carpatica* (LOZYNIAK), *Eucyrtidium*(?) *ozaiense, Mirifusus mediodilatatus* (RÜST), *Podocapsa amphitreptera* FOREMAN and so on. The radiolarian association of the sample is characteristic of *Pseudodictyomitra* cf. *carpatica* Assemblage, according to our zonal scheme. The association also characterizes the *Ditrabs sansalvadorensis* Zone by AITA & OKADA (1984 and in prep.), which is assigned to late Tithonian to Valanginian on the basis of the Maiolica Limestone samples. Therefore, the *P. primitiva—P.* sp. A Assemblage, which is placed biostratigraphically just below the *P.* cf. *carpatica* Assemblage, is older than late Tithonian. *Hsuum maxwelli* PESSAGNO is considered extinct within lower Tithonian (PESSAGNO, 1977a). Judging from the above-mentioned association, it is suggested that the *P. primitiva—P.* sp. A Assemblage is assigned to Tithonian. Age assignment of the Torinosu Group and its equivalents in the Sakawa and the Kii-Yura areas on the basis of ammonites is compatible with that by means of radiolarians.

Comparison with other radiolarian assemblages

The following three radiolarian assemblages have been proposed as the latest Jurassic and/or earliest Cretaceous ones by other workers in Japan; namely (1) the *Parvicingula altissima* Assemblage from the Shimanto Belt (NAKASEKO *et al.*, 1979; NAKASEKO & NISHIMURA, 1982), (2) the *Mirifusus baileyi* Assemblage from the Mino Terrane (MIZUTANI *et al.*, 1981; MIZUTANI, 1981), and (3) the *Mirifusus mediodilatatus—Pseudodictyomitra* cf. *carpatica* Assemblage from the Southern Chichibu Terrane in Kyushu (NISHIZONO *et al.*, 1982; NISHIZONO & MURATA, 1983).

(1) NAKASEKO & NISHIMURA (1982) assigned the *P. altissima* Assemblage to Tithonian time on the basis of the occurrence of *P. altissima* (RÜST). However, the specimen identified with *P. altissima* (RÜST) by NAKASEKO *et al.* (1979) and NAKASEKO & NISHIMURA (1982) is more similar to *Parvicingula cretacea* BAUMGARTNER which is restricted within the Berriasian and the Valanginian (BAUMGARTNER *et al.*, 1980). The *"P. altissima"* Assemblage may be better compared with the *Pseudodictyomitra* cf. *carpatica* Assemblage.

(2) The *Mirifusus baileyi* Assemblage (MIZUTANI, 1981) is composed of many species common to *P. primitiva—P.* sp. A Assemblage and rarely contains an older element such as *Hsuum maxwelli* PESSAGNO which is found in the *Tricolocapsa* sp. O Assemblage

and older assemblages of Middle to middle Late Jurassic age in Japan. The *Mirifusus baileyi* Assemblage can be compared not only the *P. primitiva—P.* sp. A Assemblage but also with the *Tricolocapsa* sp. O Assemblage.

(3) The *Mirifusus mediodilatatus—Pseudodictyomitra* cf. *carpatica* Assemblage (NISHIZONO *et al.*, 1982; NISHIZONO & MURATA, 1983) contains *P.* sp. cf. *P. carpatica* (LOZYNIAK) and *Eucyrtidium*(?) sp. C. Therefore the assemblage is comparable with the *P.* cf. *carpatica* Assemblage.

Acknowledgements

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(JE); in Japanese with English abstract, (J); in Japanese.

Explanation of Plate 1

(Figures ×213, except for figs. 15–21)

The number in parentheses indicates the reference number of photograph.

Figs. 1–6. *Pseudodicytomitra primitiva* Matsuoka & Yao, n. sp.

1. Y–VI906–14–4,4/8 (250–8b) OCU MR 2730
2. Y–VI906–14–4,2/1 (250–1a) OCU MR 2731
3. Y–VI906–14–4,6/6 (251–9a) OCU MR 2732
4. Y–XIV927–11–1,12/14 (215–7a) OCU MR 2733
5. Y–VI906–14–4,2/8 (249–6b) OCU MR 2734
6. Y–VI906–14–1,93 (126–7) OCU MR 2735

Figs. 7–10. *Solenotryma*(?) *ichikawai* Matsuoka & Yao, n. sp.

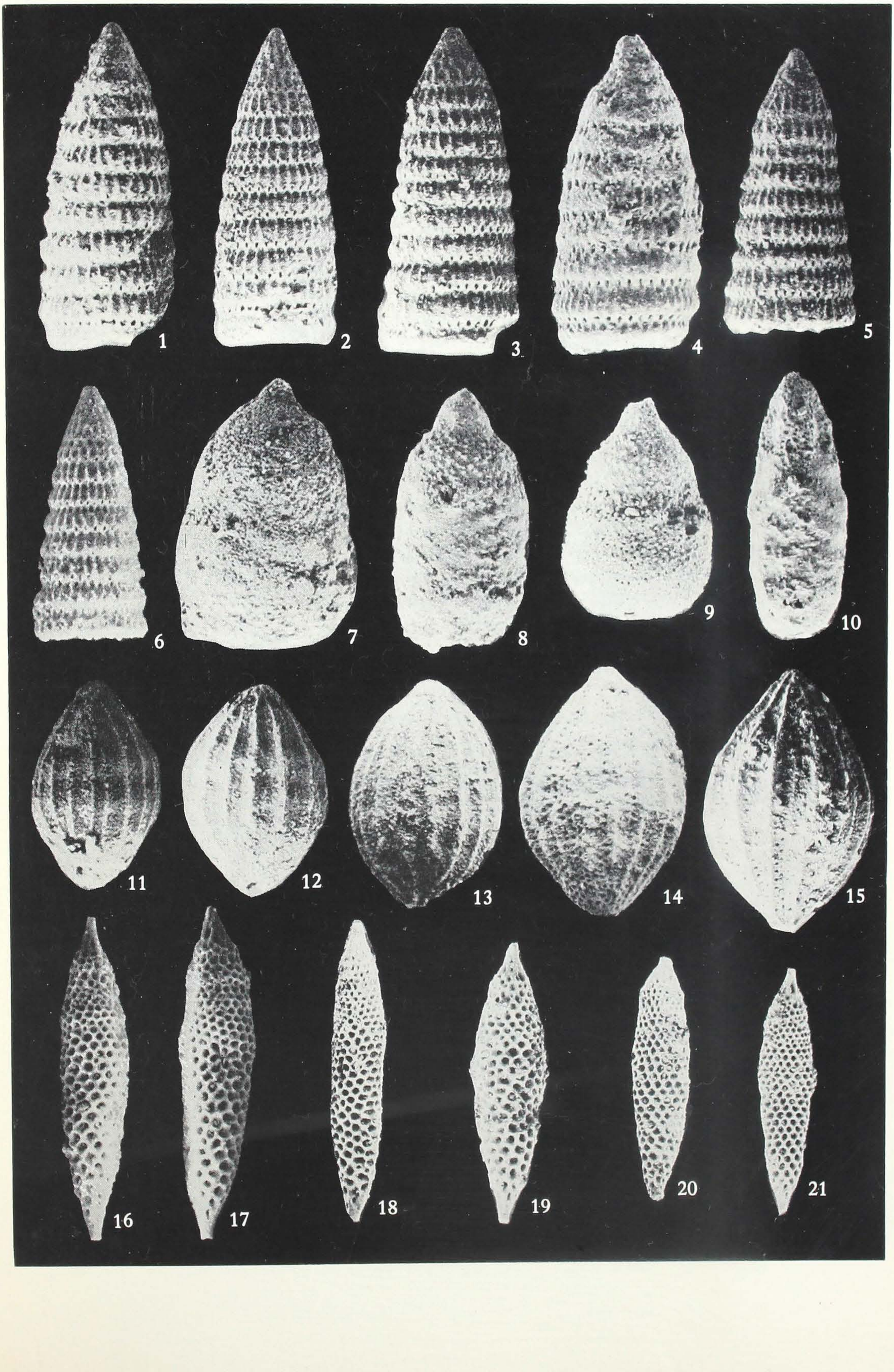
7. Y–VI906–14–4,2/6 (249–7a) OCU MR 2750
8. Y–XIV927–11–1,2/10 (209–9b) OCU MR 2751
9. Y–XIV927–11–1,5/3(211–3b) OCU MR 2752
10. Y–XIV927–11–1,6/5 (212–1a) OCU MR 2753

Figs. 11–15. *Protunuma japonicus* Matsuoka & Yao, n. sp.

11. Y–VI906–14–4,2/7 (249–7a) OCU MR 2740
12. Y–VI906–14–4,3/7 (250–3b) OCU MR 2741
13. Y–VI906–14–4,3/4 (250–2b) OCU MR 2742
14. Y–VI906–14–2,5/12 (222–3a) OCU MR 2743
15. Y–VI906–14–4,7/11 (252–6) OCU MR 2744 ×225

Figs. 16–21. *Pseudoeucyrtis reticularis* Matsuoka & Yao, n. sp.

16. Y–VI906–14–1,108 (127–7b) OCU MR 2758 ×142
17. Y–VI906–14–1,110 (127–8b) OCU MR 2759 ×142
18. Y–VI906–14–2,5/14 (222–1b) OCU MR 2760 ×100
19. Y–VI906–14–2,5/15 (222–2a) OCU MR 2761 ×142
20. Y–VI906–14–2,5/11 (222–1a) OCU MR 2762 ×100
21. Y–VI906–14–2,2/16 (218–9a) OCU MR 2763 ×100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Explanation of Plate 2

Fig. 1. *Parvicingula mashitaensis* MIZUTANI
Y–VI906–14–3,1/9 (243–8) ×142

Fig. 2. *Mirifusus mediodilatatus* (RÜST)
Y–XIV927–11–1,1/7 (209–6) ×100

Fig. 3. *Spongocapsula* sp. A
Y–VI906–14–2,1/2 (218–2) ×142

Fig. 4. *Archaeodictyomitra apiara* (RÜST)
Y–XIV927–11–1,12/5 (215–10a) ×213

Fig. 5. *Archaeodictyomitra minoensis* (MIZUTANI)
Y–XIV927–11–1,12/6 (215–9b) ×213

Figs. 6–7. *Pseudodictyomitra* (?) sp. D
6. Y–VI906–14–2,12/5 (219–3b) ×213
7. Y–VI906–14–4,8/10 (252–5b) ×213

Fig. 8. *Eucyrtidium*(?) *ptyctum* RIEDEL & SANFILIPPO
Y–VI906–14–3,7/9 (248–4) ×300

Fig. 9. *Foremanella diamphidia* (FOREMAN)
Y–XIV927–11–2,2/5 (249–8) ×213

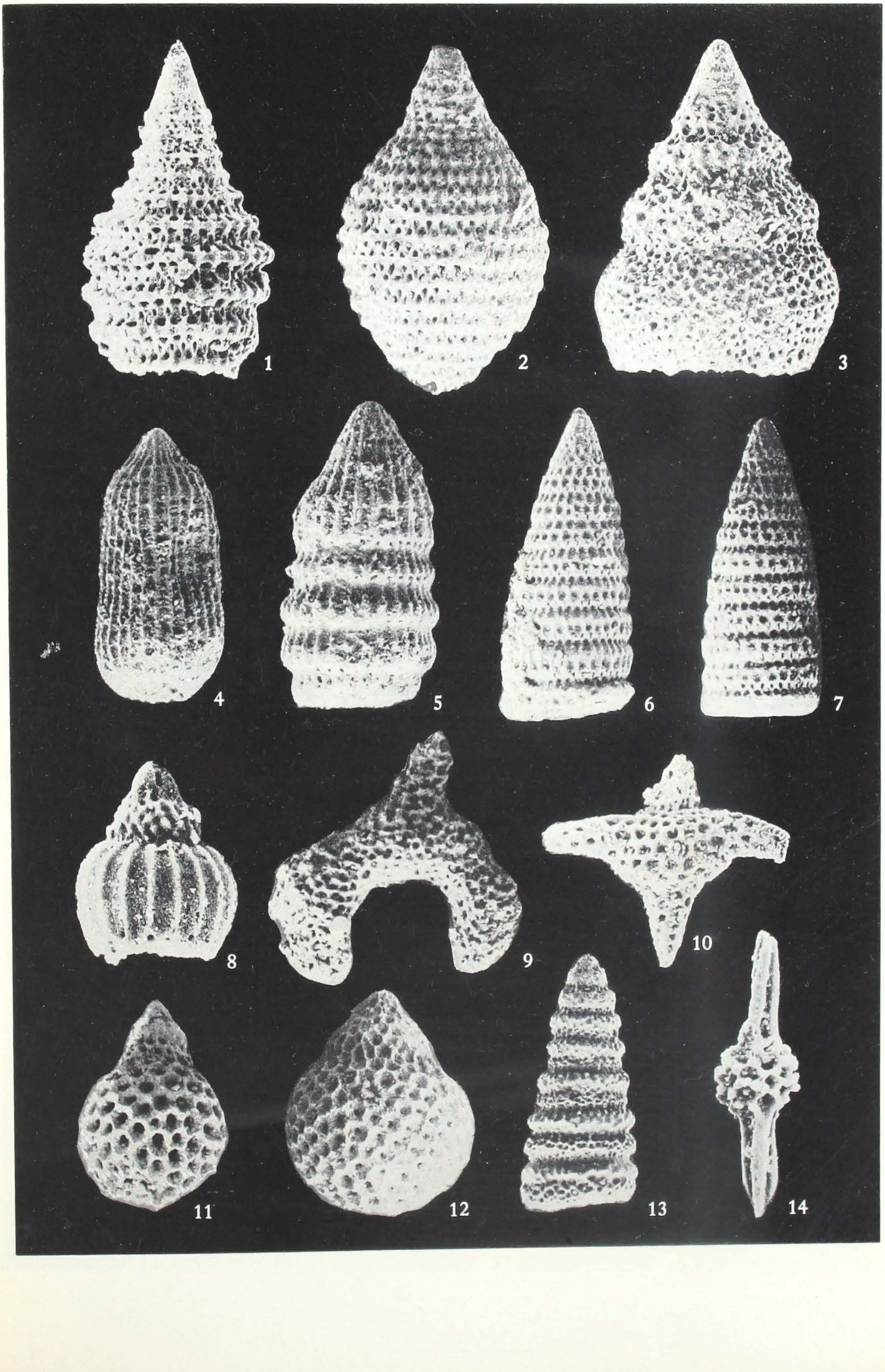
Fig. 10. *Podocapsa amphitreptera* FOREMAN
Y–VI906–14–3,1/9 (243–2) ×100

Fig. 11. *Stichocapsa* sp. A
S–VI2801–49,3/2 (1396) ×200

Fig. 12. *Tricolocapsa* sp. A
S–III1403–106, 7/2 (4547) ×300

Fig. 13. *Cinguloturris carpatica* DUMITRICA
Y–XIV927–11–1,12/4 (215–10b) ×142

Fig. 14. *Sphaerostylus* sp. A
Y–VI906–14–3,1/3 (243–7) ×142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Explanation of Plate 3

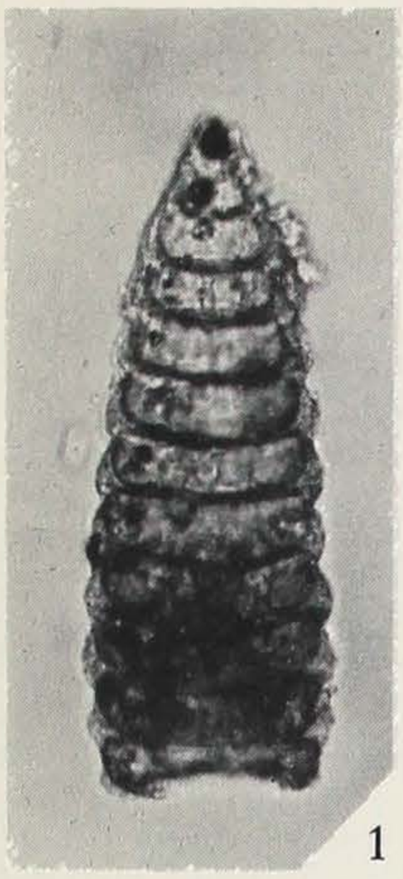
(All figures ×200)

Figs. 1–4. *Pseudodictyomitra primitiva* Matsuoka & Yao, n. sp.
1. Y–VI906–14–12,38.5/89.3 (Y85–1–25) OCU MR 2726
2. Y–VI906–14–12,34.3/90.4 (Y85–1–36) OCU MR 2727
3. Y–VI906–14–12,41.0/93.0 (Y85–2–18) OCU MR 2728 Paratype
4. Y–VI906–14–12,36.8/90.0 (Y85–1–34) OCU MR 2729 Holotype

Figs. 6–9. *Protunuma japonicus* Matsuoka & Yao, n. sp.
6. Y–VI906–14–13,45.3/93.7 (Y85–3–4) OCU MR 2736 Holotype
7. Y–VI906–14–12,39.9/90.1 (Y85–1–32) OCU MR 2737 Paratype
8. Y–VI906–14–12,42.6/89.5 (Y85–1–30) OCU MR 2738
9. Y–VI906–14–13,44.3/94.6 (Y85–3–5) OCU MR 2739

Figs. 5, 10–13. *Solenotryma*(?) *ichikawai* Matsuoka & Yao, n. sp.
5. Y–VI906–14–13,38.0/96.4 (Y85–3–19) OCU MR 2745 Holotype
10. Y–VI906–14–13,44.5/95.5 (Y85–3–14) OCU MR 2746
11. Y–VI906–14–13,42.5/94.7 (Y85–3–6) OCU MR 2747
12. Y–VI906–14–12,41.6/94.1 (Y85–2–25) OCU MR 2748 Paratype
13. Y–VI906–14–12,36.4/86.8 (Y85–1–10) OCU MR 2749

Figs. 14–17. *Pseudoeucyrtis reticularis* Matsuoka & Yao, n. sp.
14. Y–VI906–14–13,39.2/98.3 (Y85–3–27) OCU MR 2754
15. Y–VI906–14–13,38.7/99.2 (Y85–3–28) OCU MR 2755 Holotype
16. Y–VI906–14–13,41.0/99.0(Y85–3–31) OCU MR 2756 Paratype
17. Y–VI906–14–13,41.8/95.4 (Y85–3–12) OCU MR 2757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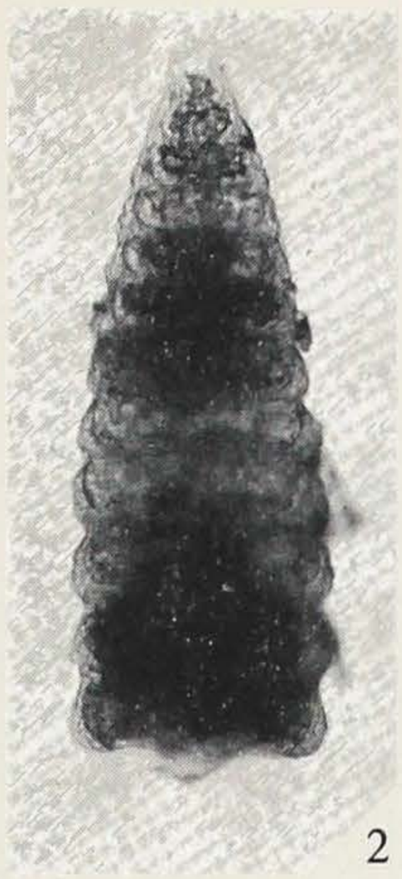
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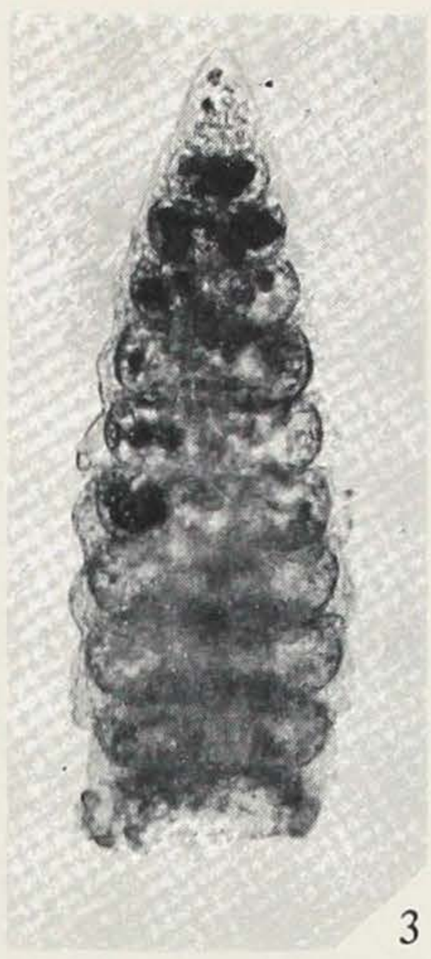
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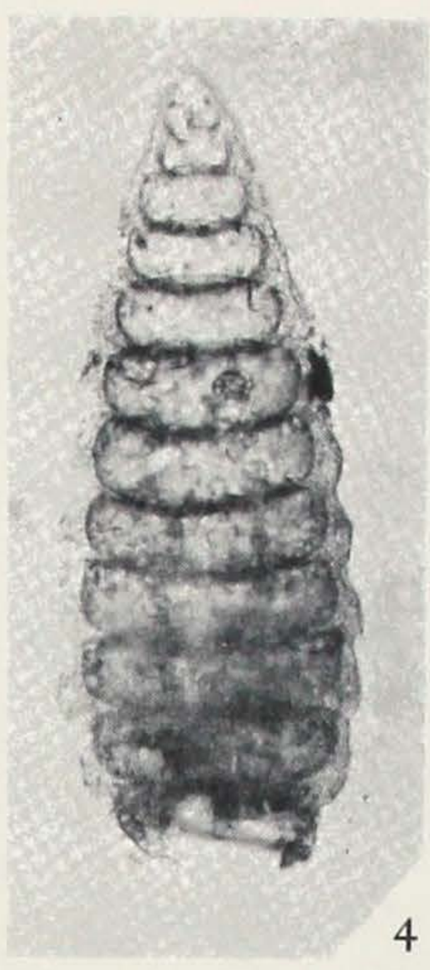
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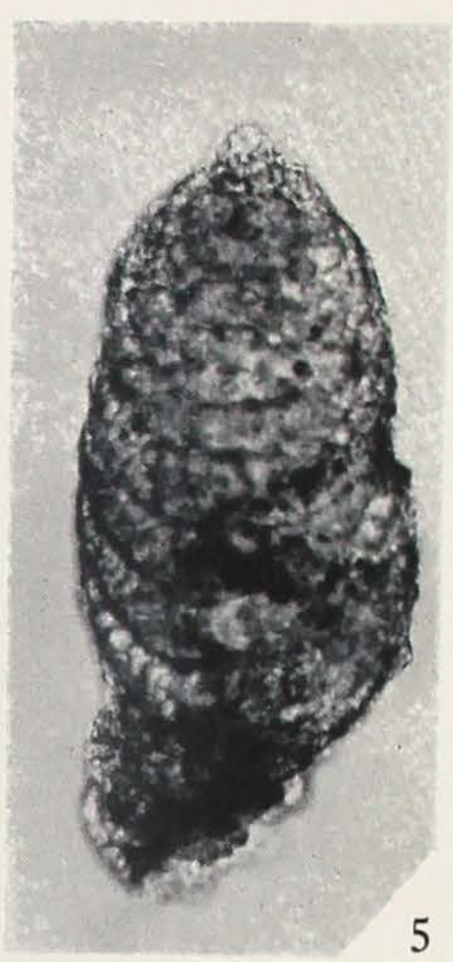
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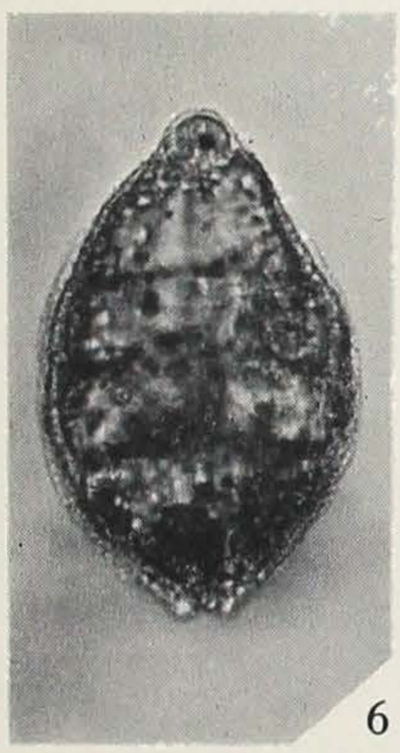
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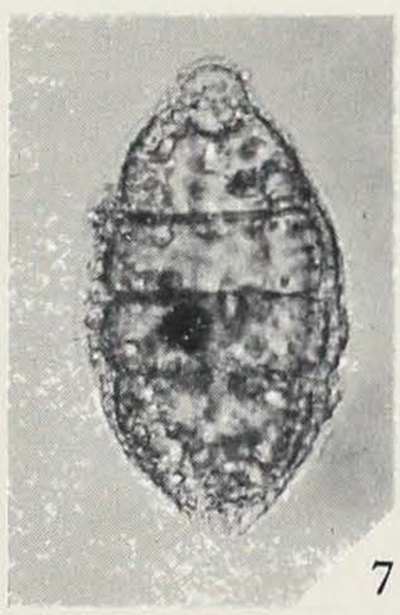
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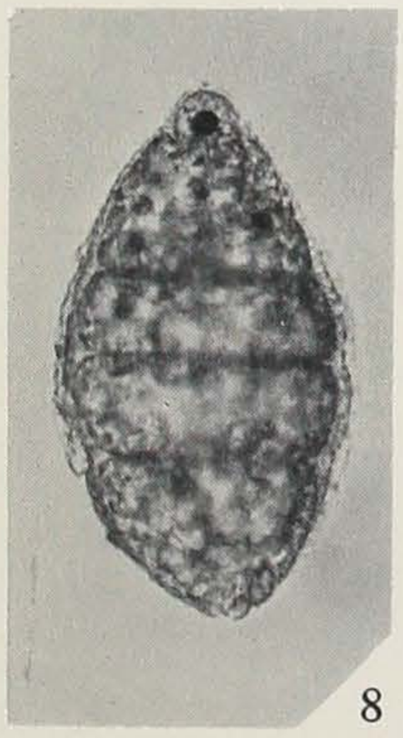
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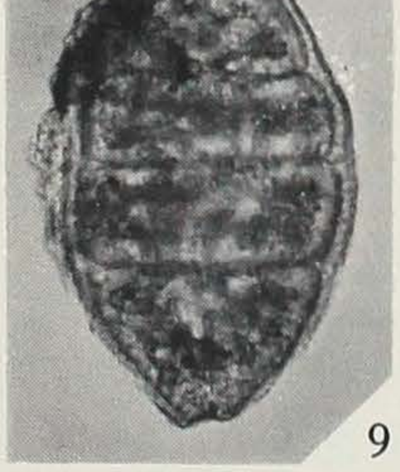
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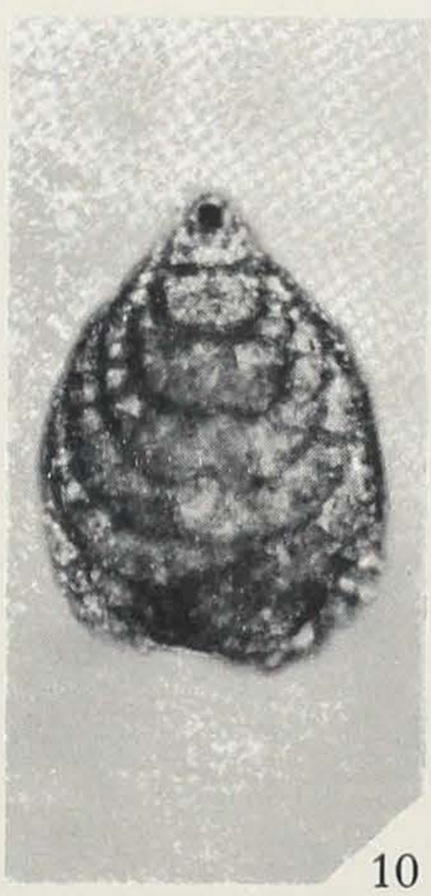
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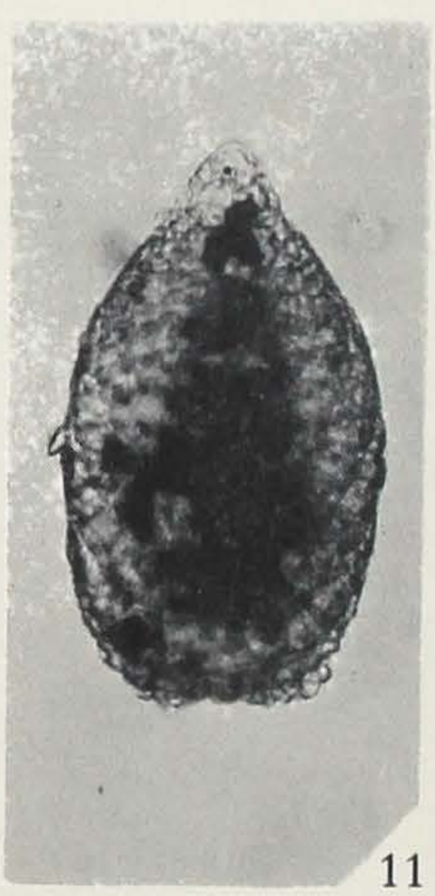
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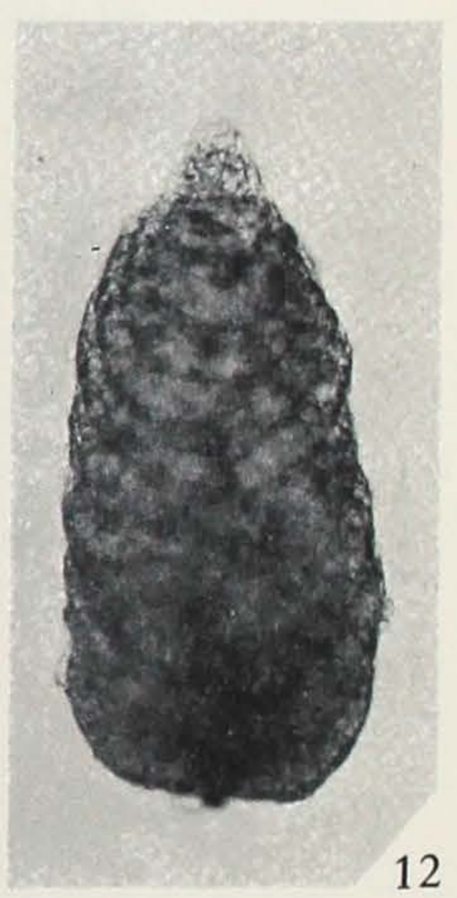
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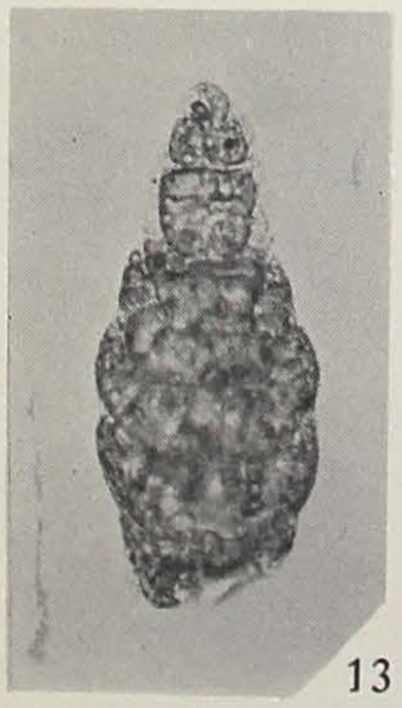
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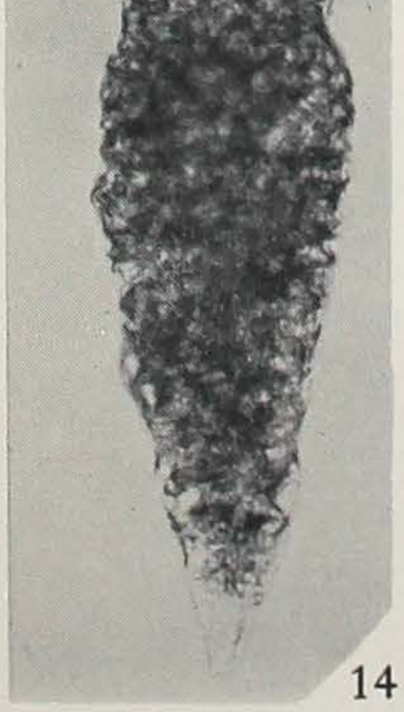
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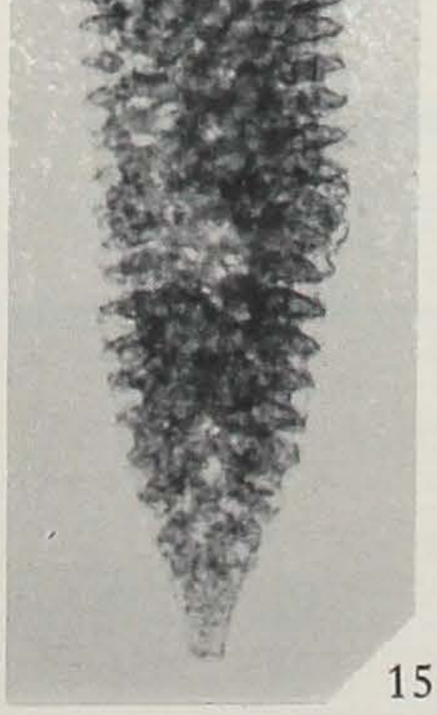
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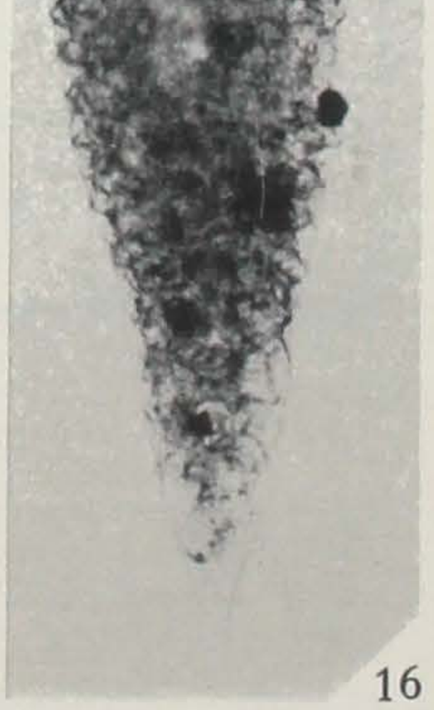
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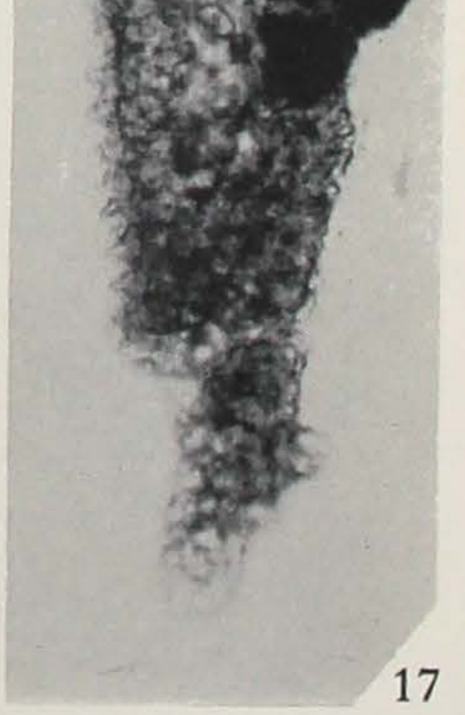
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